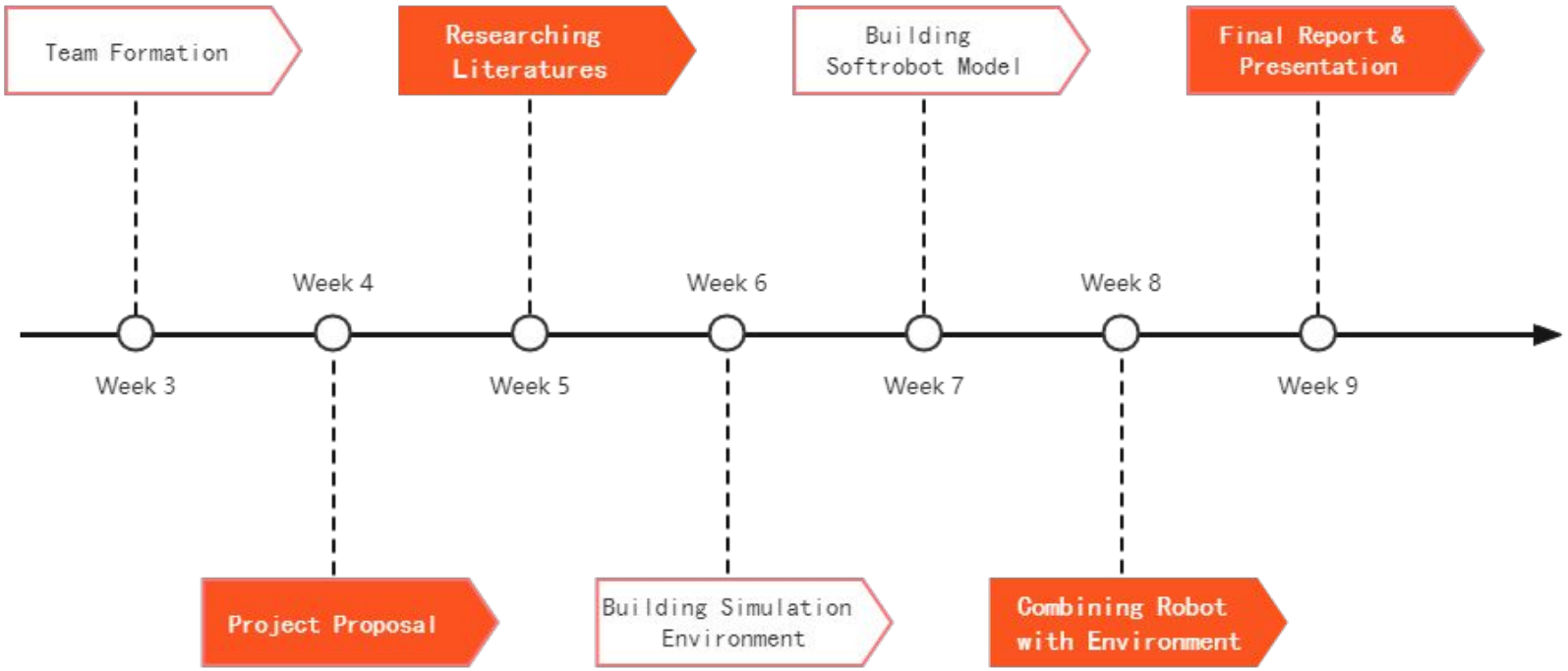
Soft Robot Motion Simulation in 2D Vascular-mimicking Network

Team 8
Mingzhang Zhu
Zhengqi Zhong
YaoHsing Tseng

Project Progress



Finished:

1. Literature Research and Review
2. Building Simulation Environment
3. Building the Soft Robot Model for one Tip Node

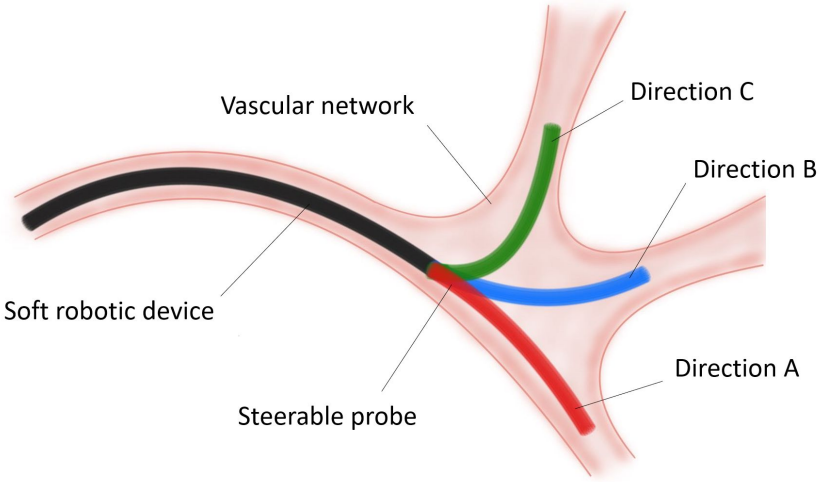
In Progress:

1. Refining DER Method on soft Robot Body
2. Combining Entire Robot with Environment

I: Introduction

- Soft robots in medical applications
  - Minimally Invasive surgery (MIS), endoscopic devices
  - Challenges: Limited accessible area

- Soft robots with steerable probe
  - Actuation: Tendon-drive, Magnet-drive
  - Unpredictable in real clinical procedure

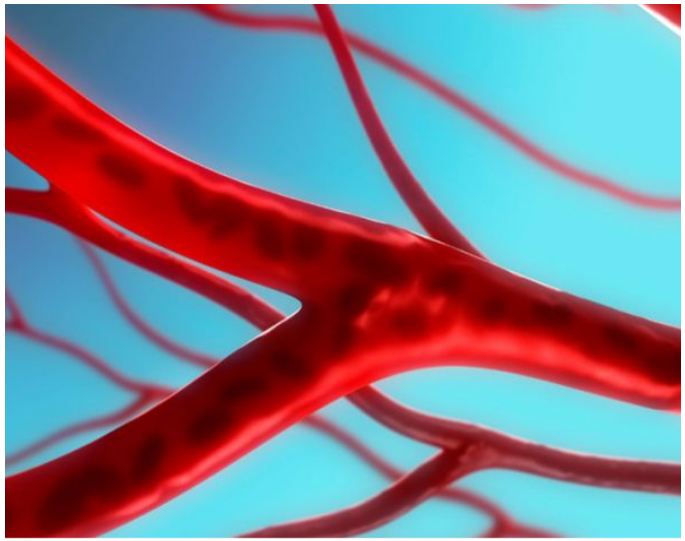


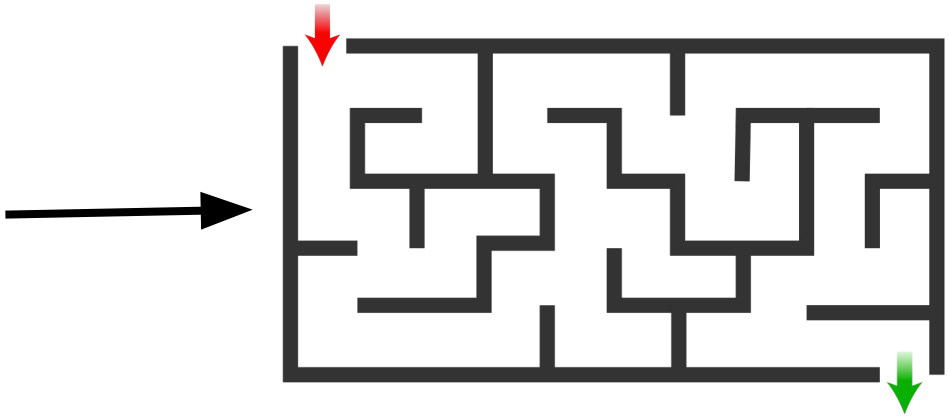
- **Solution:** Soft robots with steerable probe within complex environment

II: Design Method

II: Design Method
Vascular-mimicking Environment Model

- 2D Vascular-mimicking Environment
- Starting point to desired end point
- Square Maze (90 degree bending angle)

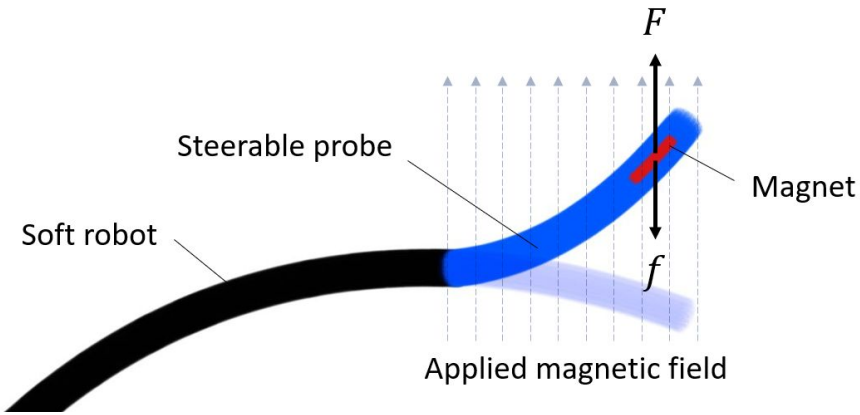




II: Design Method
Soft Continuum Robot Model

- Magnetically-driven distal steerable probe
- Driven by External Magnetic Field
- Soft Robot Body using PDMS material
- Fluid resistance:

$$f = -\frac{1}{2}\rho v^2 A C_d$$



- Equation of Motion:

$$f_i = m_i \frac{q_i(t_{k+1}) - q_i(t_k)}{dt^2} - m_i \frac{\dot{q}_i(t_k)}{dt} + \frac{\partial}{\partial q_i}\left(E_k^s + E_k^b\right) + F + f$$

- Time marching & Newton-Raphson iteraton method

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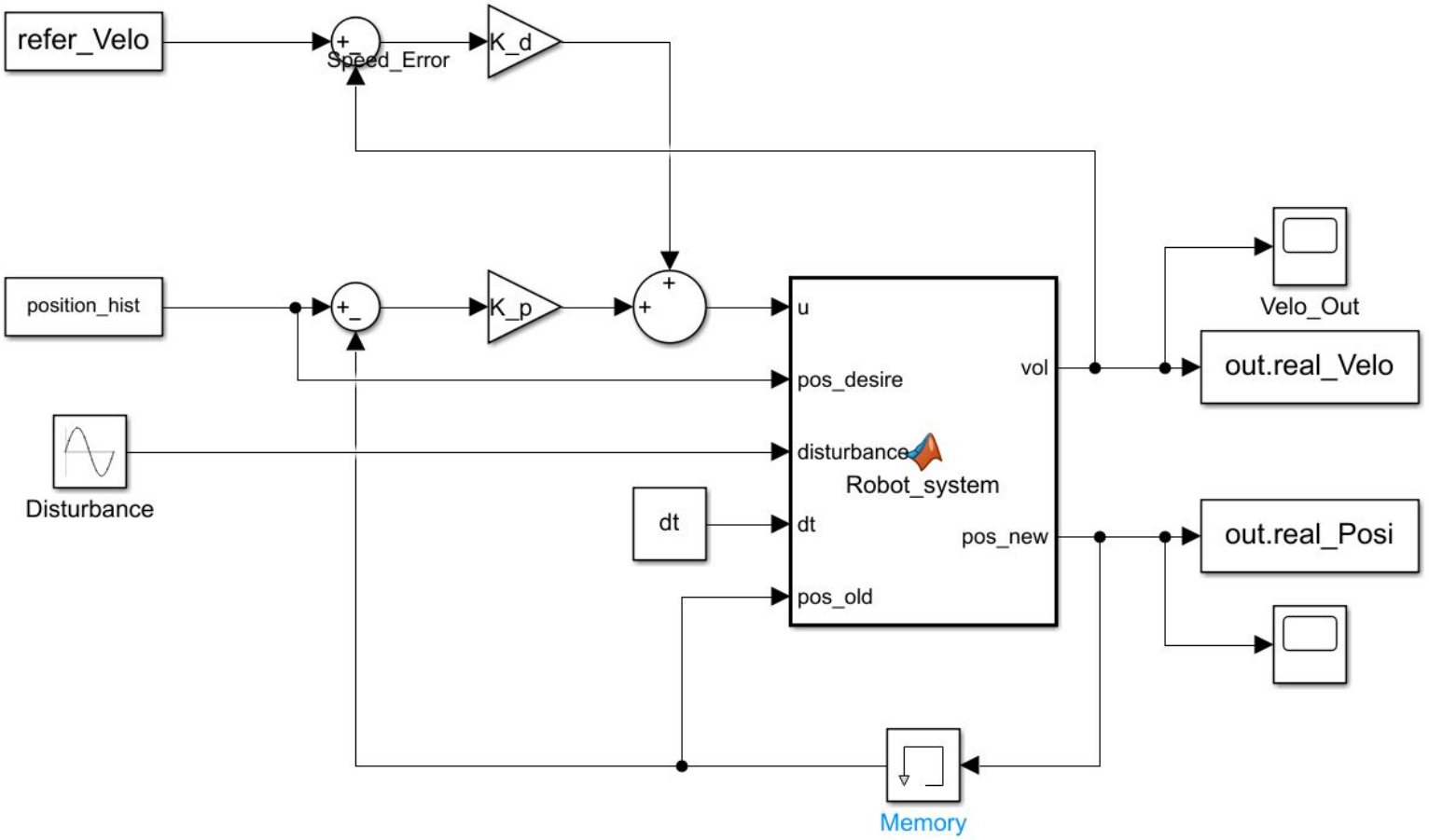
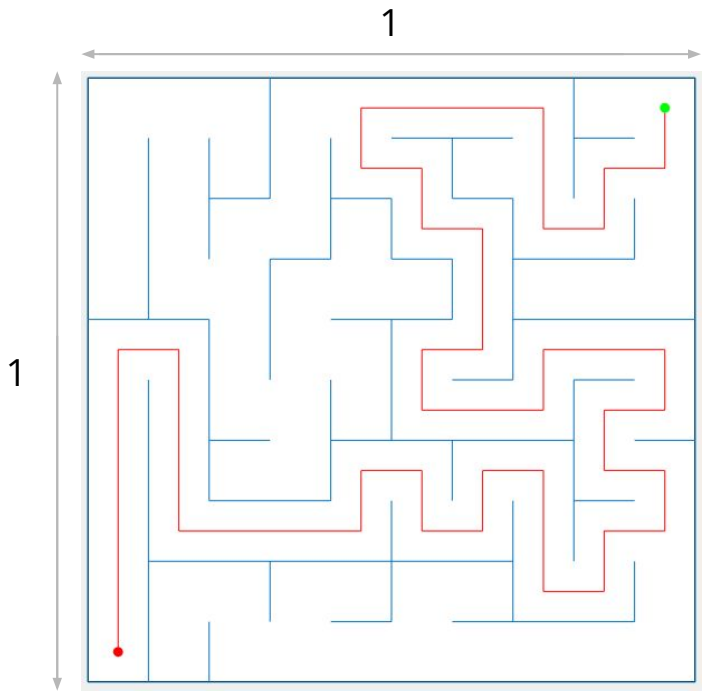
II: Design Method
Simulation Block Diagram



III: Simulation Result

III: Simulation Result Environment

1. The 2D Blood Vessel Maze Simulation
2. Starting from Low Left, Ending at Up Tight
3. Maze Size: 1 m * 1 m
4. Maze Dimention: 10*10 Blocks



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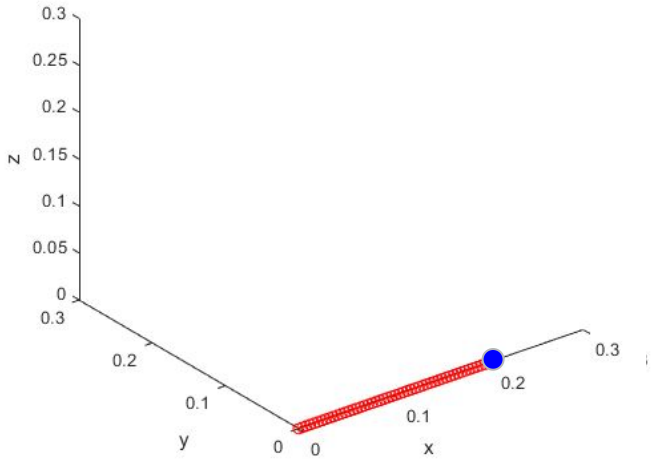
III: Simulation Result
Soft Continuum Robot Model

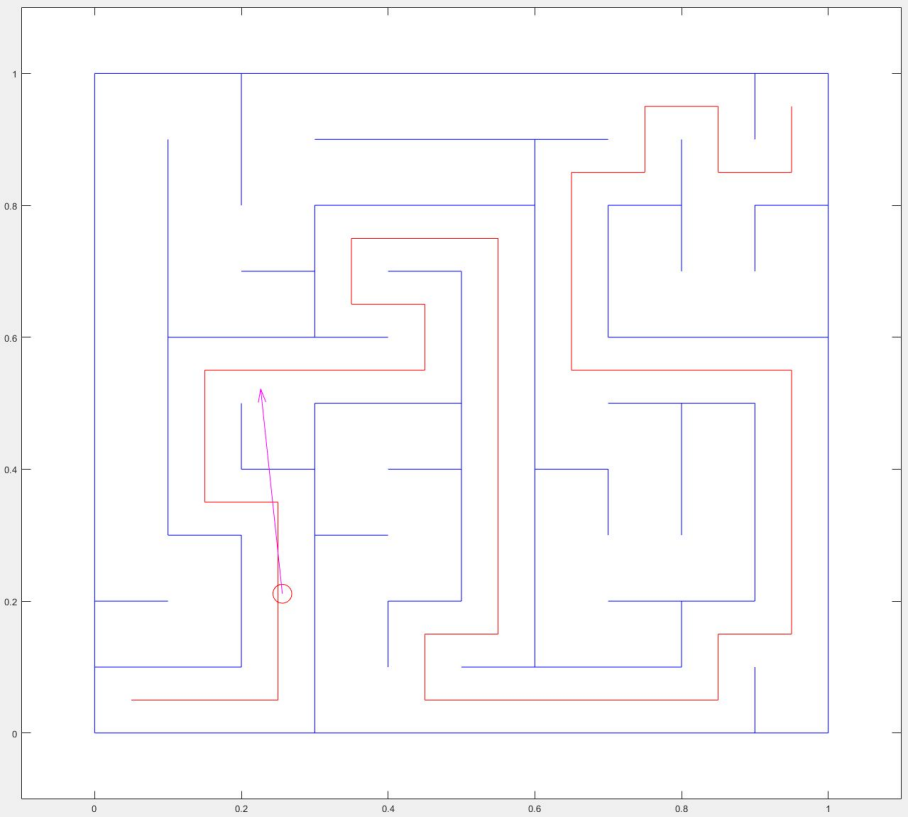
1. Length: 0.2m
2. Radius: 1mm
3. Magnetically-driven at the Robot Head
4. PDMS material



Parameter	Value
Young's Modulus	1.47 MPa
Poisson's Ratio	0.48
Shear Modulus	0.497 MPa
Density	980kg/m3

III: Simulation Result
Robot Trajectory and Force Simulation

1. We first simulated the first node of robot tips
2. The node follows the desired trajectory with Sine Wave Disturbance
3. Force Direction and Magnitude are ploted as Arrow



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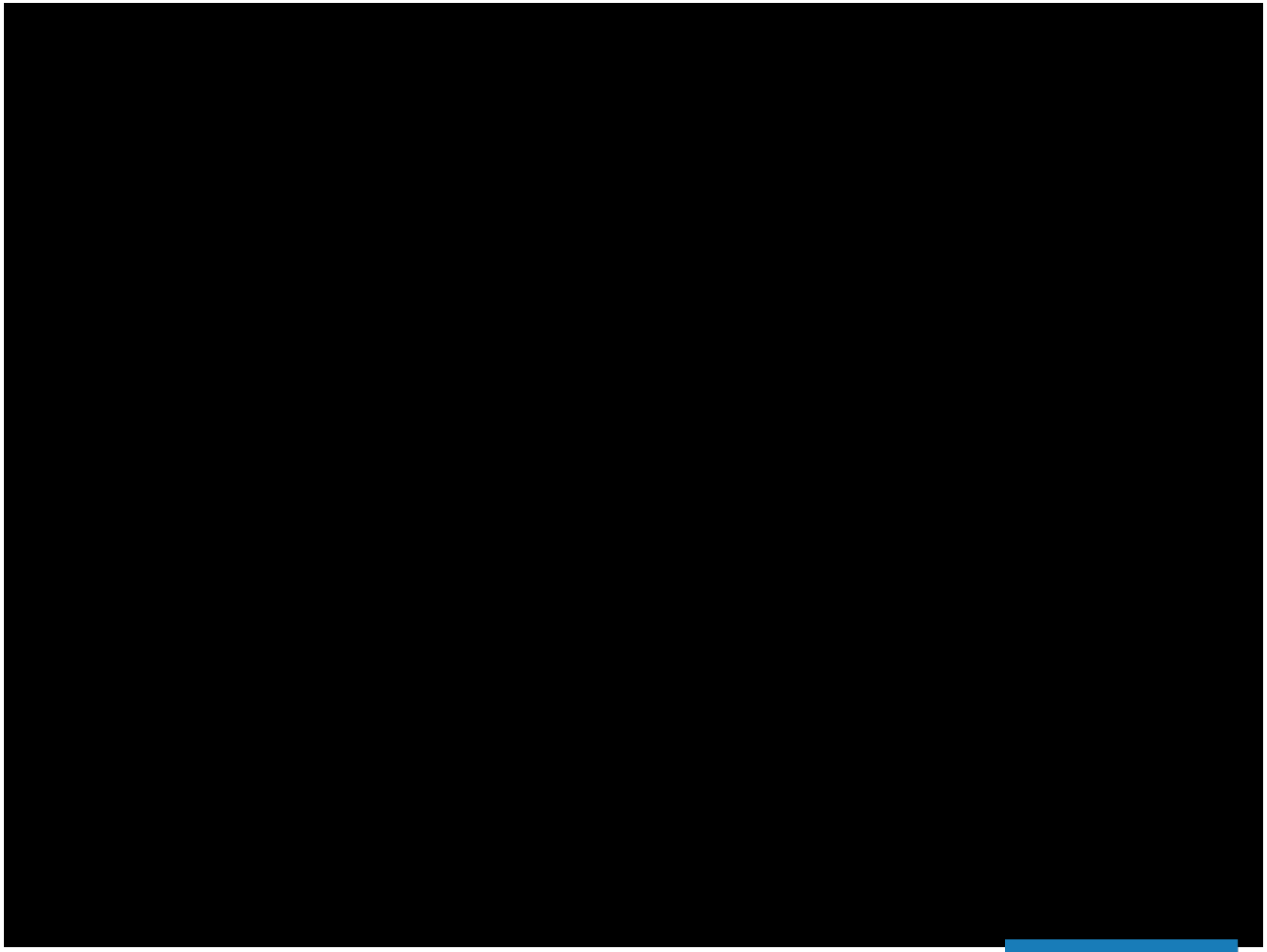
III: Simulation Result

Robot One Node Simulation Video



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IV: Discussion & Ongoing work

1. Implementing Discrete Elastic Rod (DER) Method to the Rest of Robot Body in Free Space
2. Computing the environmental force acting on the robot body
3. Simulating the Entire Soft Robot behavior under influence of Environmental External Force
4. Vascular-mimicking Environment Iteration

Thankyou